THE INTERRELATIONS OF ANIMALS AND PLANTS AND THEIR INFLUENCE UPON THE FOOD SUPPLY OF MAN

By Professor ROBERT W. HEGNER

THE JOHNS HOPKINS UNIVERSITY

CHARLES DARWIN in the "Origin of Species" gives several interesting examples of the "complex relations of all animals and plants to each other in the struggle for existence."[1] One of these is very frequently cited, namely, that of the influence of cats upon the clover crop, since cats catch field mice, and field mice destroy more than two thirds of the bees which are alone instrumental in pollenizing red clover. What will happen when the equilibrium of nature is disturbed by the introduction or extermination of a certain species of plant or animal, is in any case difficult to predict. We know comparatively little about the biological results of changes in the fauna and flora, but certain of the more direct effects of one sort of organism upon the welfare of another in a widely different sphere of life have been carefully worked out. Some of the relations revealed are indeed startling and, economically considered, effectually transpose many apparently harmless organisms into the highly injurious class. Of particular interest at the present time are those relations between organisms that influence the food supply of man.

We are all most familiar with the animals that may be used directly as food. Among these are the domesticated mammals, such as the cattle, sheep and pigs, and mammals that are still wild but have been hunted extensively in the past for food and some of which are still of value in certain localities. Among these are the opossum, the bear, seals, squirrels, rabbits, muskrats, woodchucks, deer, moose, caribou, elk, mountain sheep and mountain goats.

The domesticated birds are only second to the domesticated mammals in food value. Most important of these are the chickens, geese, ducks, guinea fowls, turkeys and pigeons. As among the mammals, there are many wild birds that might form part of our bill of fare, but unfortunately we have in the

[1] "The Origin of Species," 6th edition, 1872, pp. 55–59.

past so thoughtlessly abused this "inexhaustible" natural resource that now the grouse, bobwhites, pheasants, turkeys, wild ducks, wild geese, plovers, snipes and wild pigeons are all but exterminated and are of practically no value to us.

Among the principal reptiles of food value are the turtles, such as the diamond-back terrapin, soft-shelled turtle and green turtle.

The amphibia are of very little importance, furnishing us only frogs' legs. Efforts have been made to carry on frog "farming," but these have not been very successful in close quarters, because the frogs eat each other, and their food, of small animals, can be obtained for them only with difficulty.

Fish, on the other hand, have been for centuries one of man's most abundant food resources, and both the federal and state governments are now expending large sums to plant new waters or to restock depleted fishing grounds.

Shellfish, likewise, have figured strongly on human bills of fare from the days of primitive man to the present time. Oysters have been particularly favored. Other shellfish that are commonly eaten by human beings are the soft-shell clam, razor-shells, hen clams, mussels and scallops. Certain large snails are considered a delicacy, especially by the French, and squids are eaten by some people, particularly the Chinese and Italians.

The sea serves as a pasture for many species of edible Crustacea. Of these the most important are the lobsters, blue crabs, and shrimps. Freshwater crayfishes are not used as extensively as food, but the growing scarcity of lobsters makes it probable that raising crayfishes for market may soon become a flourishing industry.

It is evident from the above list that man has in the past been indebted for much of his food supply to wild animals, which have come to him with no more effort than that required to capture and distribute them, and this list has been presented simply to remind us of the extent of our indebtedness to them.

Not only are many kinds of animals used directly as food by man, but certain of them manufacture food products that we would greatly miss if we were deprived of them, such as milk, butter, cheese, eggs and honey.

Each of these food animals has its own particular part to play in the struggle for existence, and its value to us makes its enemies our enemies. Among the most conspicuous destructive animals are the predacious mammals. The relations

of predacious mammals to other animals and to man are very complex and each species must be examined separately in order to determine its economic status. Space allows us, however, only room for a few general statements. Where uninfluenced by the presence of man, a balance is struck between these flesh-eaters and the herbivorous animals upon which they prey. Often their activities are of real benefit, since vast numbers of rabbits, mice and other harmful species are destroyed by them. The more important predacious mammals are the wolf, coyote, mountain lion, bear, lynx, fox and mink. The wolf is particularly destructive in localities where domesticated animals are reared in large numbers. Lack of their natural food, which formerly consisted of wild game, principally bison, has decreased their numbers almost to the vanishing point, and the relentless war waged upon them by man has all but exterminated them. Wolves and coyotes also have beneficial qualities, since they destroy prairie dogs, ground squirrels and other harmful rodents, but these are far outweighed by their destruction of wild game and domesticated animals. Mountain lions kill deer, young elk and other food animals. The bear and lynx are too rare to be of much importance; the fox and the mink prey upon both wild and domesticated birds, but often pay for their depredations by destroying obnoxious insects, field mice, ground squirrels and rabbits.

Less conspicuous than the predacious mammals, but of greater economic importance, are the parasitic organisms, most of which are very small, but none the less effective. Mention may be made of the threadworms, such as syngamus, which causes the disease known as gapes in poultry and game birds; and the stomach worm of the sheep; of the tapeworms, such as that of the dog, which spends part of its growth period lodged in the brain of certain food mammals—they cause "gid" or "staggers" in sheep; of the liver fluke which likewise attacks sheep; and of several extremely minute species belonging to the lowest group in the animal kingdom—the protozoa. Of the last named, one of the most important is the microscopic organism that causes Texas-fever in cattle. The life history of this organism may well serve as an illustration of the interrelations of animals widely separated in the animal series. The fever organisms or germs live in the blood corpuscles of sick cattle. They are often sucked into the bodies of ticks which infest these cattle, and after multiplying for a time, some of them become lodged in the eggs of the tick. These eggs are laid on the ground and the young germ-infested ticks that emerge from

them cling to grass blades or weeds waiting for cattle to brush against them. When this happens they fasten themselves to the animal's body and begin to suck their blood. Some of the fever germs are injected into the blood of the victim during this attack and Texas-fever in due time results. Thus this apparently insignificant organism aided by an apparently harmless tick causes an annual loss of about sixty million dollars to the people living in the fever district and a corresponding decrease of our food supply.

The control of the Texas-fever tick is very simple. The adult ticks die after laying their eggs, and the young die if they do not gain access to cattle within a few months. A pasture may thus be freed from ticks if left vacant for a few months. Ticks may also be removed from cattle by dipping the animals in vats containing substances such as crude petroleum or arsenical mixtures which kill the ticks.

Animals that destroy or lessen the value of food plants and their products are frequently overlooked. Every one who has attempted to raise garden vegetables or fruit knows what constant attention is necessary to prevent potato beetles, squash bugs, San José scales, codlin moths and other insects from preventing a harvest. So numerous and varied are these insects that the general impression arises that all insects are injurious. This however is far from true, since many parasitic species cause the death of countless harmful ones, and in fact, by holding the latter in check, are responsible for preventing the production of such mighty hordes of greedy pests that we are actually saved from starvation by their efforts.

For example, the minute tachina flies really make it possible for us to raise grain in many localities, since they destroy enormous numbers of army worms. The army worm is a black and yellow striped caterpillar about one and one half to two inches long when full-grown. It is the young of an inconspicuous dull-brown moth. Sometimes these caterpillars become so numerous that they are forced to migrate in search of food, like a foraging army. Crops over large areas are eaten by the worms with tremendous loss to the farmer and indirectly to the food-consuming public. Fortunately the tachina flies increase as rapidly as the army worms which they parasitize. Their eggs are laid on the body of the worms and the young that hatch from them burrow into their hosts, finally killing them.

Other insects are, like the bumble bee, responsible for the pollinization of flowers and consequently the production of seed.

The dependence of plants upon pollinization by insects is well illustrated by the Smyrna fig. Prior to the year 1900 this fig could not be grown in the orchards of California, but since then the causes have been found, and the remedy applied with satisfactory results. The figs did not ripen because their flowers were not pollinized. When pollination was found to be accomplished by a minute insect, this insect was introduced into the fig-growing districts of California and a successful new industry established.

Rivaling in interest the establishment of the fig industry in California is that of the salvation of the orange and lemon trees of the same origin. Kellogg gives the facts in this case in the following words:

> In 1868 some young orange trees were brought to Menlo Park (near San Francisco) from Australia. These trees were undoubtedly infested by the fluted scale which is a native of Australia. These scale immigrants throve in the balmy California climate, and particularly well probably because they had left all their native enemies far behind. By 1880 they had spread to the great orange-growing districts of southern California, five hundred miles away, and in the next ten years caused enormous loss to the growers. In 1888 the entomologist Koebele, recommended by the government division of entomology, was sent at the expense of the California fruit growers to Australia to try to find out and send back some effective predacious or parasitic enemy of the pest. As a result of this effort, a few Vedalias were sent to California, where they were zealously fed and cared for, and soon, after a few generations, enough of the little beetles were on hand to warrant trying to colonize them in the attacked orange groves. With astonishing and gratifying success the Vedalia in a very few years had so naturally increased and spread that the ruthless scale was definitely checked in its destruction, and from that time to this has been able to do only occasionally and in limited localities any injury at all.

The relations of birds to insects are known to most every one, but we can not mention too often or emphasize too strongly their influence in maintaining the equilibrium in the insect world. Much of the trouble now encountered by gardeners, horticulturists, and farmers would vanish if we could only bring back the birds that have been killed for food or driven away by various agents controlled by man, such as the domestic cat.

The decision as to what attitude to take toward any particular wild animal is indeed a difficult one. Whether to encourage it by protection or to eliminate it by paying a bounty for its capture is often a puzzling question. Among the birds the great horned owl occupies a doubtful position, sometimes being considered decidedly harmful, at other times neutral, and even beneficial. The owl feeds principally on birds and mam-

mals, and less frequently on insects. The birds are mostly game birds and poultry. There can be, of course, no doubt regarding its injurious character so far as this part of its bill of fare is concerned since all these birds are decidedly beneficial. On the other hand its mammalian food consists largely of rodents, such as mice, ground squirrels and rabbits, and an occasional skunk. Mice, ground squirrels and rabbits are among the most destructive gnawing animals, whereas the skunk may be destructive if it acquires a taste for poultry and the habit of robbing birds' nests, or it may be beneficial, feeding largely on insects and mice. Judgment regarding the great horned owl, therefore, becomes largely a matter of opinion and the conclusion is perhaps justified that in such cases it is best to regulate the number of individuals so that no notable destruction ensues. In the case of the owl, no effort is necessary since almost every hunter and farmer's boy shoots an owl on sight and thus their numbers are kept down to a minimum.

Among the many apparently useless animals that are really indispensable for the proper production of our food supply are the minute swimming animals, the Crustacea, of which the water flea is an example, and the lowly earthworm.

Although the Crustacea used as food by man in the United States are valued at several millions of dollars annually, still their indirect value as food for fish is probably greater. The smaller Crustacea furnish perhaps the principal item in the fish's bill of fare. They are extremely abundant everywhere; at one time there may be more than 250,000 in a single cubic yard of lake water or of sea water. Their effect upon the abundance of mackerel has recently been studied with the following results: The number of fish depends upon the number of Crustacea that are available for food. These Crustacea feed upon minute plants, mostly diatoms, that float about near the surface of the sea, and their abundance must depend upon the abundance of these plants. The plants require sunlight for their growth and multiplication, so that the amount of sunlight controls the number of plants. Actual observations have shown that a season of bright sunshine is followed by good fishing, and a cloudy one always results in a poor catch of mackerel.

Charles Darwin, in his book on the "Formation of Vegetable Mold through the Action of Worms," has shown, by careful observations extending over a period of forty years, how great is the economic importance of earthworms. One acre of ground may contain over fifty thousand earthworms. The

feces of these worms are the little heaps of black earth, called "castings," which strew the ground, being especially noticeable early in the morning. Darwin estimated that more than eighteen tons of earthy castings may be carried to the surface in a single year on one acre of ground, and in twenty years a layer three inches thick would be transferred from the subsoil to the surface. By this means objects are covered up in the course of a few years. Darwin speaks of a stony field which was so changed that "after thirty years a horse could gallop over the compact turf from one end of the field to the other, and not strike a single stone with its shoes."

The continuous honeycombing of the soil by earthworms makes the land more porous and insures the better penetration of air and moisture. Furthermore the thorough working over of the surface layers of earth helps to make the soil more fertile.

The need for a more detailed knowledge of such interrelations as above cited has long been recognized by the experts of the United States Department of Agriculture and by others, since there is still much to be learned. One who investigates this subject even superficially soon learns how wasteful we have been of our inexhaustible (?) resources of food animals and also of animals that protect our plants and animals from their natural enemies. May we not hope that among the benefits that we may derive from the conditions in which the world finds itself at present will be a realization of how dependent we are upon wild animals for our food supplies, and how important it is that steps should be taken for their conservation.